Biomass

What Is Biomass?

Biomass is any organic matter—wood, crops, seaweed, animal wastes—that can be used as an energy source. Biomass is probably our oldest source of energy after the sun. For thousands of years, people have burned wood to heat their homes and cook their food.

Biomass gets its energy from the sun. All organic matter contains stored energy from the sun. During a process called photosynthesis, sunlight gives plants the energy they need to convert water and carbon dioxide into oxygen and sugars. These sugars, called **carbohydrates**, supply plants and the animals that eat plants with energy. Foods rich in carbohydrates are a good source of energy for the human body!

Biomass is a **renewable** energy source because its supplies are not limited. We can always grow trees and crops, and waste will always exist.

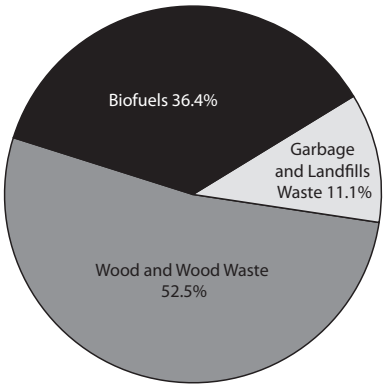
PHOTOSYNTHESIS

In the process of photosynthesis, plants convert radiant energy from the sun into chemical energy in the form of glucose (or sugar).

Water + Carbon Dioxide + Sunlight ⟶ Glucose + Oxygen

$6\,H_2O + 6\,CO_2 + \text{Radient Energy} \longrightarrow C_6H_{12}O_6 + 6\,O_2$

U.S. SOURCES OF BIOMASS 2008



Source: Energy Information Administration

Biomass at a Glance 2008

Classification:
- Renewable

Major Uses:
- electricity, transportation fuel, heating

U.S. Energy Consumption:
- 3.88 Q
- 3.9%

U.S. Energy Production:
- 3.9 Q
- 5.3%

(Most electricity from biomass is for cogeneration, and is not included in these numbers)

Types of Biomass

We use four types of biomass today—wood and agricultural products, solid waste, landfill gas and biogas, and alcohol fuels.

▪ Wood and Agricultural Biomass

Most biomass used today is home grown energy. Wood—logs, chips, bark, and sawdust—accounts for about 53 percent of biomass energy. But any organic matter can produce biomass energy. Other biomass sources include agricultural waste products like fruit pits and corncobs.

Wood and wood waste, along with agricultural waste, are used to generate electricity. Much of the electricity is used by the industries making the waste; it is not distributed by utilities, it is **co-generated**. Paper mills and saw mills use much of their waste products to generate steam and electricity for their use. However, since they use so much energy, they need to buy additional electricity from utilities.

Increasingly, timber companies and companies involved with wood products are seeing the benefits of using their lumber scrap and sawdust for power generation. This saves disposal costs and, in some areas, may reduce the companies' utility bills. In fact, the pulp and paper industries rely on biomass to meet half of their energy needs. Other industries that use biomass include lumber producers, furniture manufacturers, agricultural businesses like nut and rice growers, and liquor producers.

▪ Solid Waste

Burning trash turns waste into a usable form of energy. One ton (2,000 pounds) of garbage contains about as much heat energy as 500 pounds of coal. Garbage is not all biomass; perhaps half of its energy content comes from plastics, which are made from petroleum and natural gas.

Power plants that burn garbage for energy are called **waste-to-energy** plants. These plants generate electricity much as coal-fired plants do, except that combustible garbage—not coal—is the fuel used to fire their boilers. Making electricity from garbage costs more than making it from coal and other energy sources. The main advantage of burning solid waste is that it reduces the amount of garbage dumped in landfills by 60 to 90 percent, which in turn reduces the cost of landfill disposal. It also makes use of the energy in the garbage, rather than burying it in a landfill, where it remains unused.

▪ Landfill Gas

Bacteria and fungi are not picky eaters. They eat dead plants and animals, causing them to rot or decay. A fungus on a rotting log is converting **cellulose** to sugars to feed itself. Although this process is slowed in a landfill, a substance called methane gas is still produced as the waste decays.

New regulations require landfills to collect **methane gas** for safety and environmental reasons. Methane gas is colorless and odorless, but it is not harmless. The gas can cause fires or explosions if it seeps into nearby homes and is ignited. Landfills can collect the methane gas, purify it, and use it as fuel.

Methane, the main ingredient in natural gas, is a good energy source. Most gas furnaces and stoves use methane supplied by utility companies. In 2003, East Kentucky Power Cooperative began recovering methane from three landfills. The utility now uses the gas at five landfills to generate 16 megawatts of electricity—enough to power 7,500 to 8,000 homes.

Today, a small portion of landfill gas is used to provide energy. Most is burned off at the landfill. With today's low natural gas prices, this higher-priced **biogas** is rarely economical to collect. Methane, however, is a more powerful greenhouse gas than carbon dioxide. It is better to burn landfill methane and change it into carbon dioxide than release it into the atmosphere.

Methane can also be produced using energy from agricultural and human wastes. **Biogas digesters** are airtight containers or pits lined with steel or bricks. Waste put into the containers is fermented without oxygen to produce a methane-rich gas. This gas can be used to produce electricity, or for cooking and lighting. It is a safe and clean-burning gas, producing little carbon monoxide and no smoke.

Biogas digesters are inexpensive to build and maintain. They can be built as family-sized or community-sized units. They need moderate temperatures and moisture for the fermentation process to occur. For developing countries, biogas digesters may be one of the best answers to many of their energy needs. They can help reverse the rampant deforestation caused by wood-burning, and can reduce air pollution, fertilize over-used fields, and produce clean, safe energy for rural communities.

Use of Biomass

Until the mid-1800s, wood gave Americans 90 percent of the energy used in the country. Today, biomass provides about 3.9 percent of the total energy we consume. Biomass has largely been replaced by coal, natural gas, and petroleum.

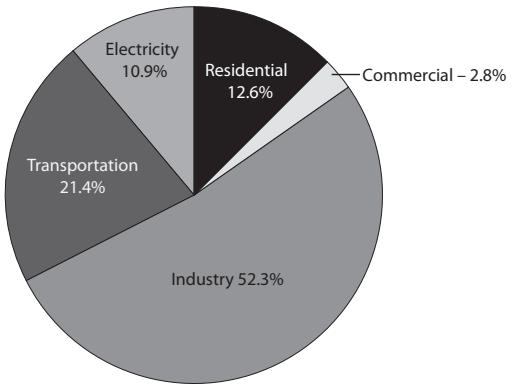
Half of the biomass used today comes from burning wood and wood scraps such as saw dust. Another third is from biofuels, principally ethanol, that is used as a gasoline additive. The rest comes from crops, garbage, landfill gas.

Industry is the biggest user of biomass. Almost 53 percent of biomass is used by industry. Electric utilities use 10.9 percent of biomass for power generation. Biomass produces 1.4 percent of the electricity we use.

Transportation is the next biggest user of biomass; almost 22 percent of biomass is used by the transportation sector to produce ethanol and biodiesel.

The residential sector uses 12.6 percent of the biomass supply. about one-fifth of American homes burn wood for heating, but few use wood as the only source of heat. Most of these homes burn wood in fireplaces and wood stoves for additional heat.

2008 U.S. BIOMASS CONSUMPTION BY SECTOR OF THE ECONOMY



Source: Energy Information Administration

Using Biomass Energy

Usually we burn wood and use its energy for heating. Burning, however, is not the only way to convert biomass energy into a usable energy source. There are four ways:

Fermentation: There are several types of processes that can produce an alcohol (ethanol) from various plants, especially corn. The two most commonly used processes involve using yeast to ferment the starch in the plant to produce ethanol. One of the newest processes involves using enzymes to break down the cellulose in the plant fibers, allowing more ethanol to be made from each plant, because all of the plant tissue is utilized, not just the starch.

Burning: We can burn biomass in waste-to-energy plants to produce steam for making electricity, or we can burn it to provide heat for industries and homes.

Bacterial Decay: Bacteria feed on dead plants and animals, producing methane. Methane is produced whenever organic material decays. Methane is the main ingredient in natural gas, the gas sold by natural gas utilities. Many landfills are recovering and using the methane gas produced by the garbage.

Conversion: Biomass can be converted into gas or liquid fuels by using chemicals or heat. In India, cow manure is converted to methane gas to produce electricity. Methane gas can also be converted to methanol, a liquid form of methane.

Biomass and the Environment

Environmentally, biomass has some advantages over fossil fuels such as coal and petroleum. Biomass contains little sulfur and nitrogen, so it does not produce the pollutants that can cause acid rain. Growing plants for use as biomass fuels may also help keep carbon dioxide levels balanced. Plants remove carbon dioxide—one of the **greenhouse gases**—from the atmosphere when they grow.

Biomass: Ethanol

What is Ethanol?

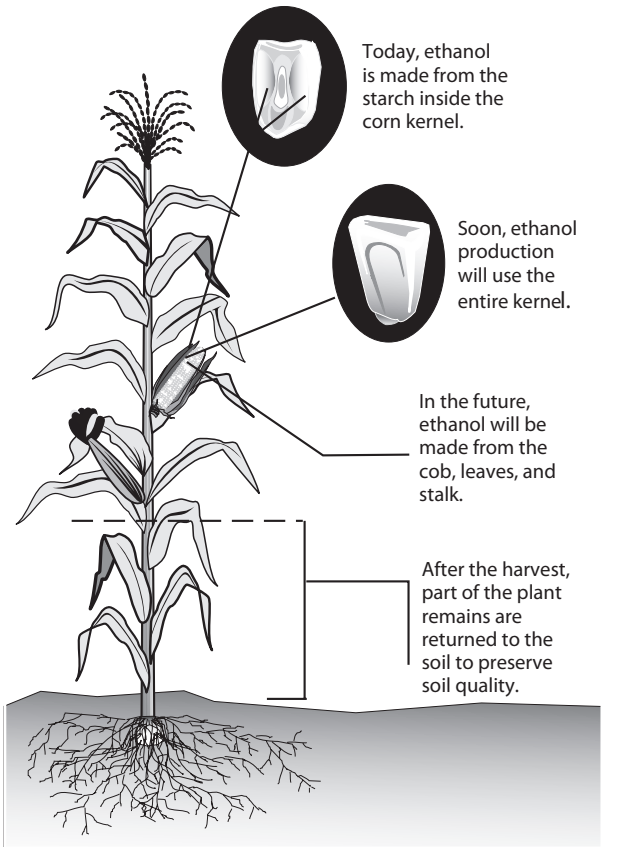
Ethanol is an alcohol fuel made by fermenting the sugars found in grains, such as corn and wheat, as well as potato wastes, cheese whey, corn fiber, rice straw, sawdust, urban wastes, and yard clippings.

There are several processes that can produce alcohol (ethanol) from the various plant forms of biomass. The two most commonly used processes involve using yeast to ferment the sugars and starch in the feedstock (corn or wheat) to create ethanol. This is how wine, beer, and liquor are made. Cider, for example, is made by fermenting apple juice.

Another uses enzymes to break down the cellulose in woody fibers so that more of the plant waste can be used to make ethanol.

This technology makes it possible to make ethanol from trees, grasses, and crop residues. Trees and grasses require less energy to produce than corn, which must be replanted and tended every year.

CORN PLANT



Scientists have developed fast-growing, hybrid trees that can be harvested in ten years or less. Many perennial grasses can be established in one year and can produce two harvests a year for many years. These new energy crops will not require constant tending or fertilizers, and their root systems will rebuild the soil. They will also prevent erosion and offer habitats for wild animals.

Soon, you may find yourself driving by huge farms that are not producing food or animal feed, but fuel for ethanol and power plants. These energy crops will be a boon to the American farmer. In recent years, advances in farming have allowed farmers to produce enough food for the country on much less land. In fact, American farmers export forty percent of the food they grow and still have plenty of land that is not under production.

History of Ethanol

Ethanol is not a new product. In the 1850s, nearly 90 million gallons were produced every year. At the beginning of the Civil War, a $2.08 per gallon tax was imposed on liquor to finance the war. Since ethanol is a product of fermentation, it was taxed as liquor.

At the same time, competitors such as kerosene and methanol were taxed at only 10 cents a gallon. As a result, ethanol could not compete as a fuel and disappeared from the market.

In 1906, the federal liquor tax was repealed and ethanol became competitive as a fuel. In 1908, Henry Ford designed his Model T Ford to run on a mixture of gasoline and alcohol, calling it the fuel of the future.

During World War I, the use of ethanol increased rapidly and, by the end of the war, production had risen to 50 million gallons a year. It was used not only as a fuel, but in the manufacture of war materials as well.

In 1919, the ethanol industry received another blow when the era of Prohibition began. Since ethanol was considered liquor, it could only be sold when poisons were added to make it undrinkable. In a process called denaturing, ethanol was rendered poisonous by the addition of three–five percent petroleum components.

By the 1920s, ethanol was no longer thought of as an alternative to gasoline; it was considered a gasoline extender or octane enhancer that boosts the power of the car's engine. However, with the production of ethanol effectively banned by Prohibition, other products were used for that purpose.

With the end of Prohibition in 1933, interest in the use of ethanol as a fuel was revived. During World War II, production of ethanol rose dramatically to 600 million gallons a year. While some ethanol was used as fuel, most was used in the production of synthetic rubber, since supplies of natural rubber had been cut off by the war in Asia.

After the war, ethanol production again declined sharply. Not only were there no more government contracts to produce ethanol, but farmers were exporting much of their grain. At the same time, large supplies of cheap foreign oil made gasoline less expensive.

Ethanol Today

In the 1970s, embargoes by major oil producing countries curtailed gasoline supplies, which revived interest in ethanol as an alternative fuel. In 2008, over 200 ethanol plants in 26 states, mostly in the Midwest, produce about nine billion gallons of ethanol.

Another reason for the renewed interest in ethanol is its environmental benefit as a vehicle fuel. Since ethanol contains oxygen, using it as a fuel additive results in lower carbon monoxide emissions.

Today ethanol is commonly blended into 70 percent of the gasoline sold in the U.S. Gasoline containing 10 percent (E10) is widely used in areas that fail to meet air quality standards. Fuel containing 85% ethanol and 15% gasoline (E85) qualifies as an **alternative fuel.** There are about seven million flexible fuel vehicles (FFV) on the road that can run efficiently on E85. In 2008 there were over 1,600 E85 fueling stations in 40 states. Each FFV using E85 as a fuel keeps over 4,000 lbs. of greenhouse gases from entering the atmosphere.

It costs more to produce ethanol than gasoline, but federal and state tax advantages make ethanol use competitive in the marketplace. As new technologies for producing ethanol from all parts of plants and trees become available and economical, the production and use of ethanol should increase dramatically.

ETHANOL VEHICLES IN USE TODAY

THE CARBON CYCLE FOR BIOFUELS